Solar System with SPICA

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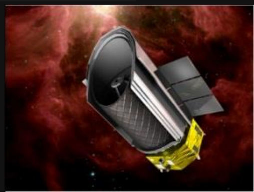
IR Space telescopes vs Planetary Science (1)

- Solar System main science is made by dedicated Space missions
  - Few targets visited In Situ
- SPICA can
  - Characterise all the other interesting targets
  - Study the variability overt time of SS targets
  - Make follow-up observations impossible to perform in situ



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IR Space telescopes vs Planetary Science (2)

- For IR space telescopes such as ISO, Spitzer, Hubble Space Telescope, Herschel, Planetary science issues are usually a secondary goal
- Usually large main belt asteroids are observed as “photometric calibrators”
- Nevertheless, high number of publication in high impact factor Journals (1988-2012: 420 papers)
- Many outstanding results were obtained

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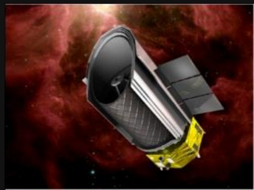
IR Space telescopes vs Planetary Science (3)

- MB asteroids, Centaurs and Trans neptunians science
  - Spitzer 51, HST 62, Herschel 15, ISO 17
- Comets study
  - Spitzer 33, HST 82, Herschel 7, ISO 13
- Dust ring discoveries and analysis
  - Spitzer 1, HST 14
- Giant planet Atmospheres study
  - Spitzer 1, HST 110, Herschel 5, ISO 10



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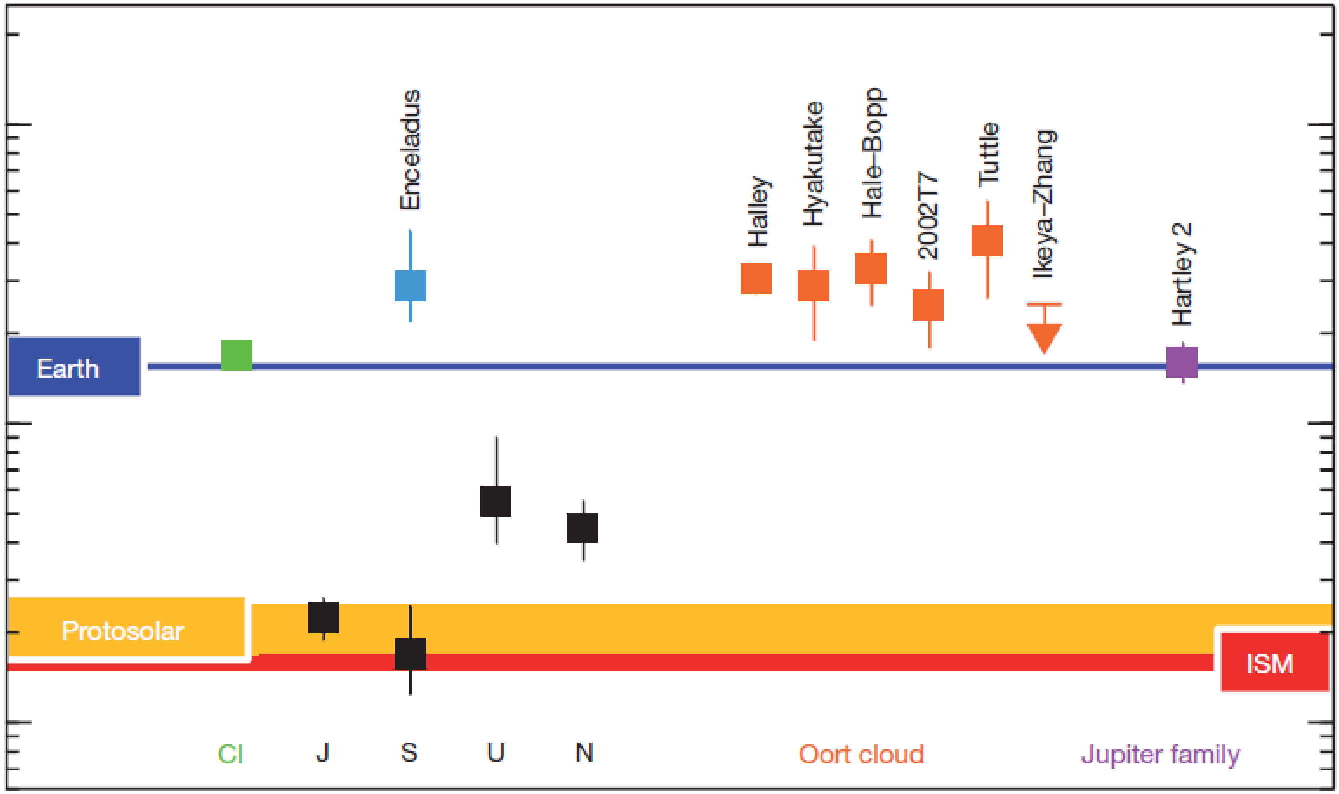
Nature 2011 151 citations *(source Scopus)*

doi:10.1038/nature1

Ocean-like water in the Jupiter-family comet 103P/Hartley 2

Paul Hartogh[1], Dariusz C. Lis[2], Dominique Bockelée-Morvan[3], Miguel de Val-Borro[1], Nicolas Biver[3], Michael Küppers[4], Martin Emprechtinger[2], Edwin A. Bergin[5], Jacques Crovisier[3], Miriam Rengel[1], Raphael Moreno[3], Slawomira Szutowicz[6] & Geoffrey A. Blake



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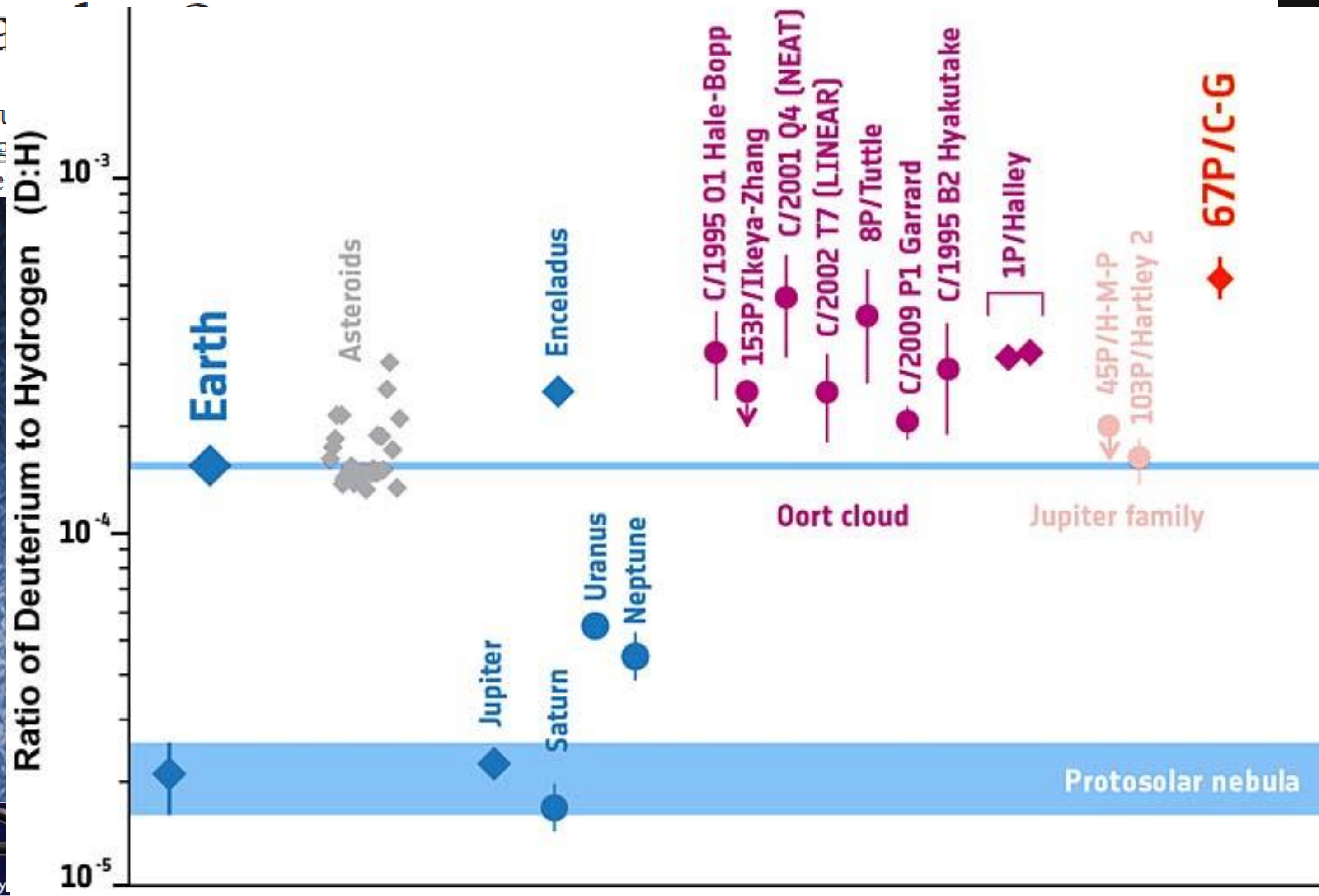
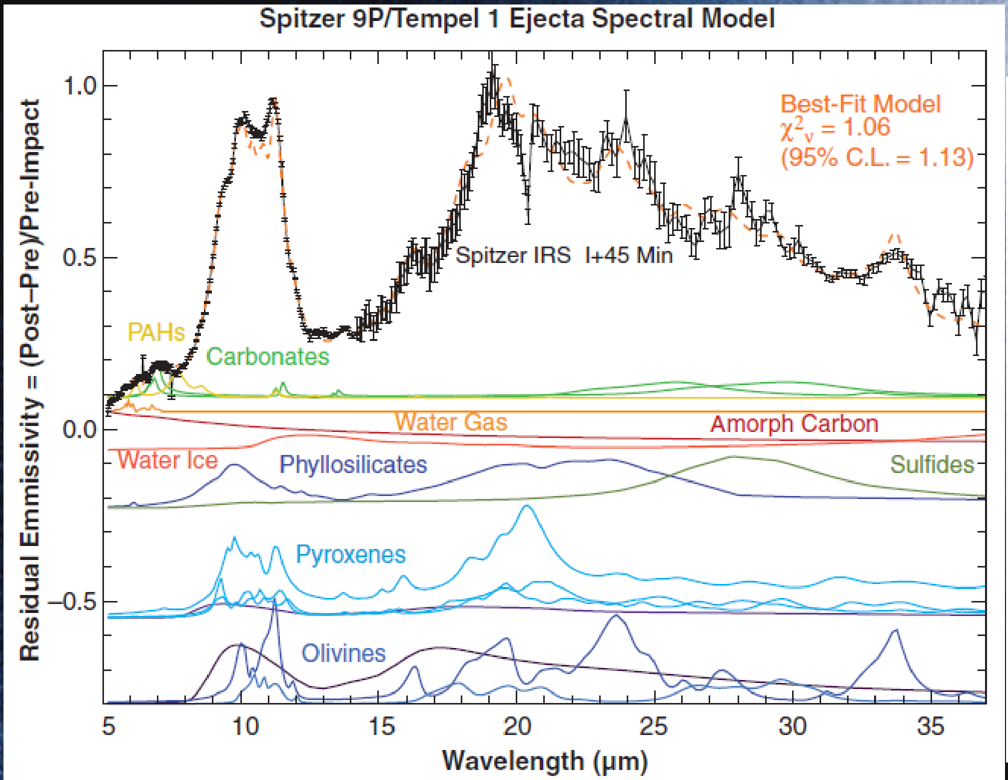


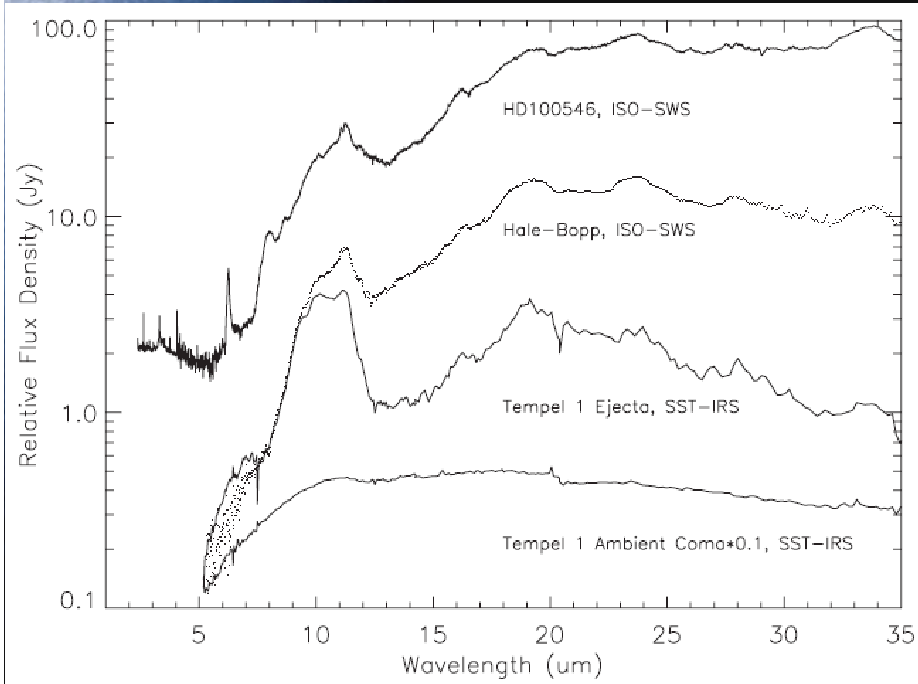
Spitzer Spectral Observations of the Deep Impact Ejecta

Science 2006

191 citations *(source Scopus)*

C. M. Lisse,[1,2*] J. VanCleve,[3] A. C. Adams,[3] M. F. A'Hearn,[2] Y. R. Fernández,[4] T. L. Farnham,[2] L. Armus,[5] C. J. Grillmair,[5] J. Ingalls,[5] M. J. S. Belton,[6] O. Groussin,[2] L. A. McFadden,[2] K. J. Meech,[7] P. H. Schultz,[8] B. C. Clark,[9] L. M. Feaga,[2] J. M. Sunshine[2]





Spica vs Solar System Objectives

- MB asteroids, Centaurs and Trans neptunian science
  - Surface mineral composition, physical (e.g. size, mass, orbital parameters, albedo) and thermal properties (inertia, beaming factor)
- Comets study
  - Coma, tail, nucleus and ejecta investigations
  - dust mineral composition
  - Volatiles degassing rate
  - Gas isotopic ratios
- Dust ring discoveries and analysis
  - Saturn and Jupiter ring, discovery of new dust ring/torus (e.g. Mars)
- Giant planet Atmospheres study
  - Search for minor organic species (Uranus, Neptune)

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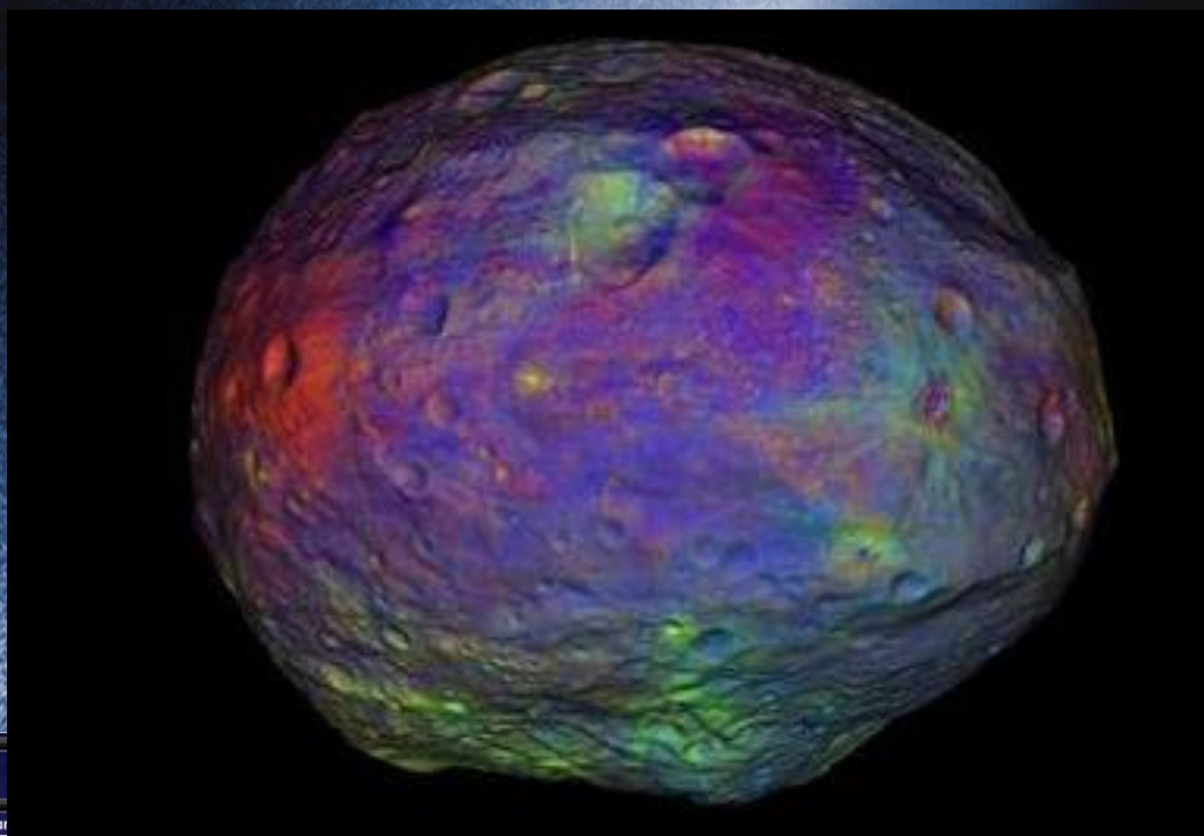
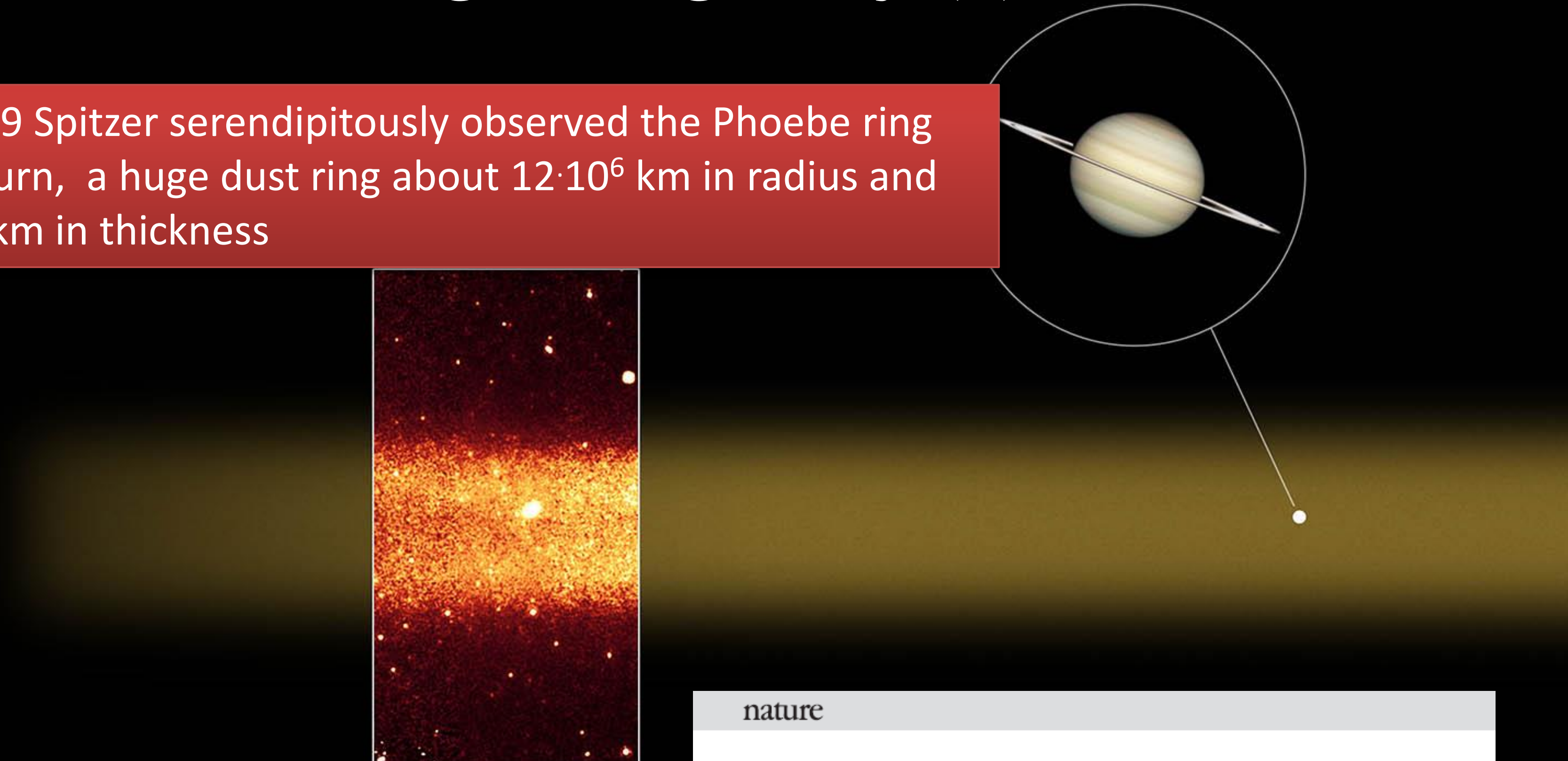
SPICA future observations: three examples

1. Saturn largest ring study
2. Vesta and Ceres investigations
3. Martian dust torus detection & study



Saturn largest ring study (1)

In 2009 Spitzer serendipitously observed the Phoebe ring of Saturn, a huge dust ring about $12 \cdot 10^6$ km in radius and $3 \cdot 10^6$ km in thickness



nature

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Saturn's largest ring

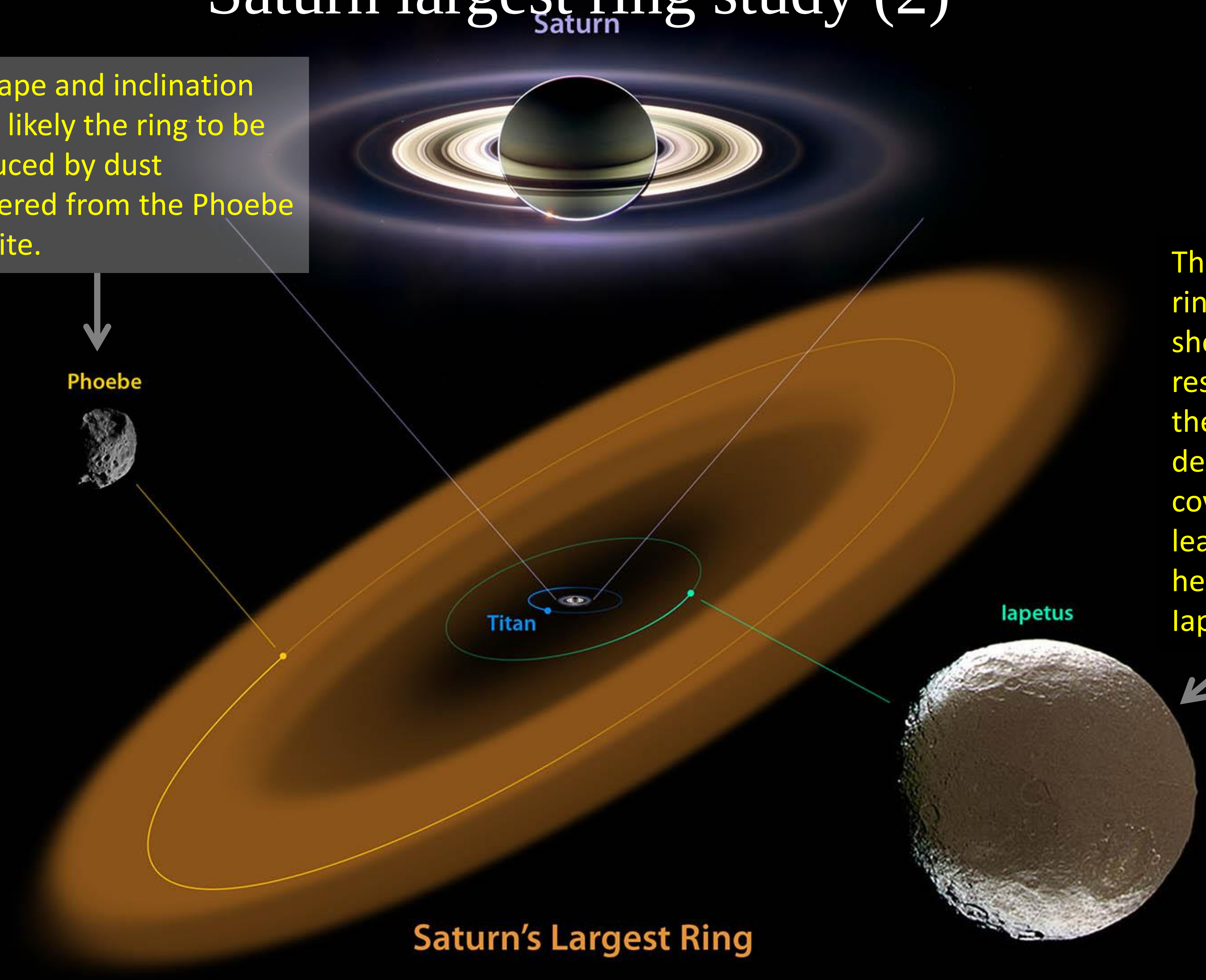
Anne J. Verbiscer[1], Michael F. Skrutskie[1] & Douglas P. Hamilton[2]

Infrared View of Saturn's Largest Ring
NASA / JPL-Caltech / A. Verbiscer (Univ. of Virginia)

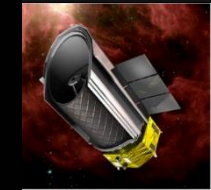
Spitzer Space Telescope • MIPS
ssc2009-19a

Saturn largest ring study (2)

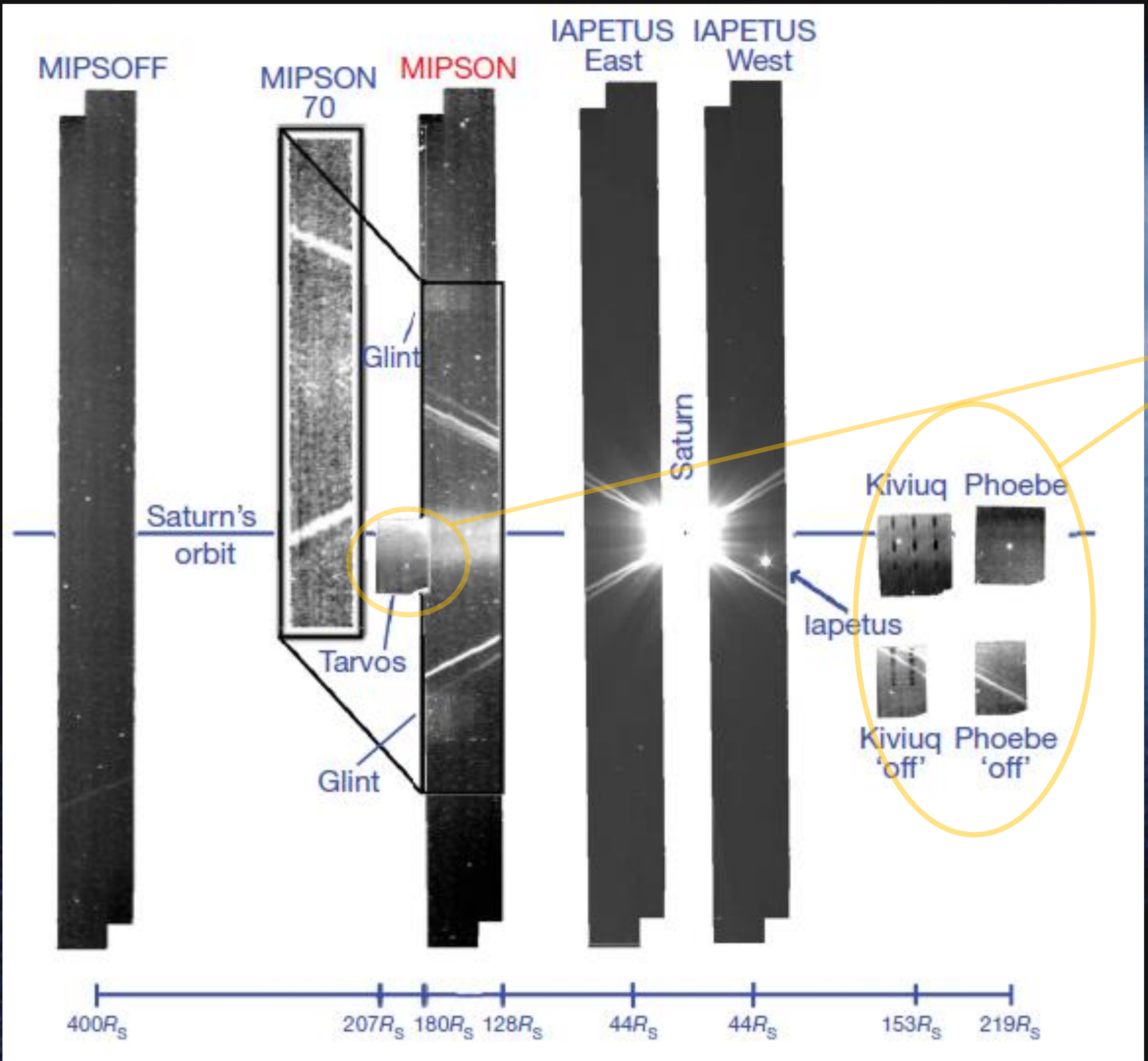
Its shape and inclination make likely the ring to be produced by dust sputtered from the Phoebe satellite.



The infall of ring material should be responsible of the dark deposits covering the leading hemisphere of Iapetus.

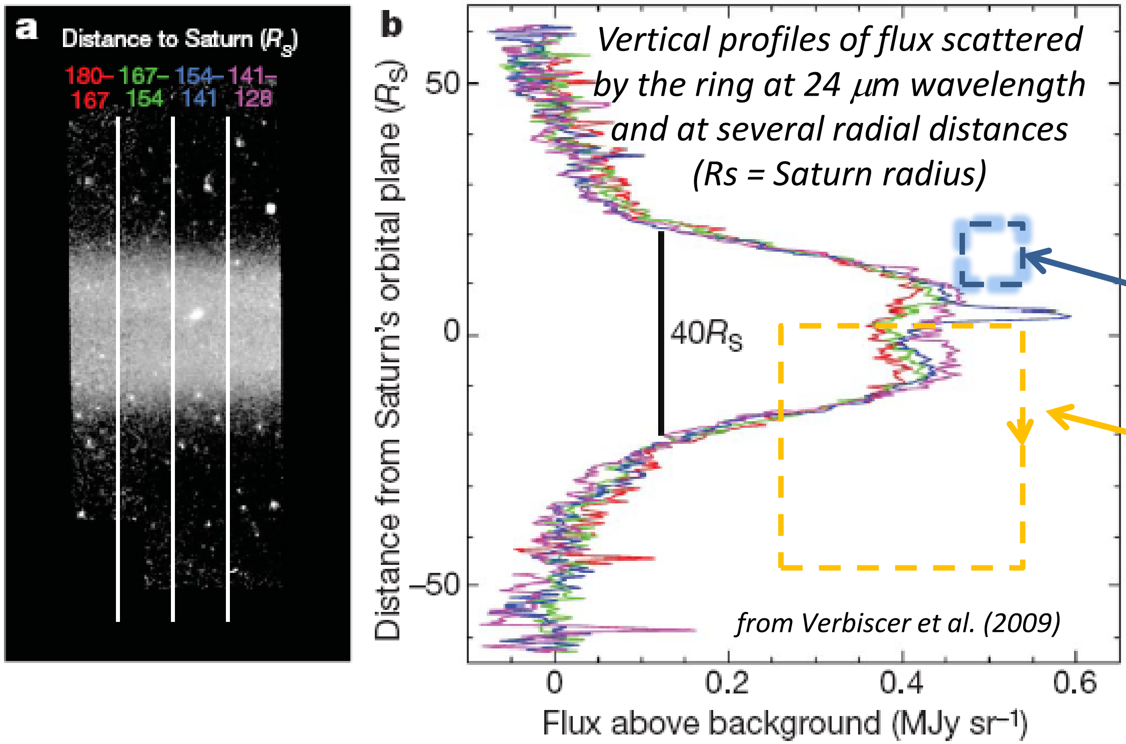


Saturn largest ring study (3)



MIPS indipendent observations

Saturn largest ring study (5)



SAFARI FoV: 120 arcsec ~ 14Rs

SMI FoV ~ 600 arcsec ~ 68 Rs

The imager instruments proposed for SPICA should be able to sample the Phoebe ring at high resolution in its full extension…

…casting light on the grain size distribution of the ring particles and their thermal properties, better constraining their origin, their dynamical behaviour and the age of the system.

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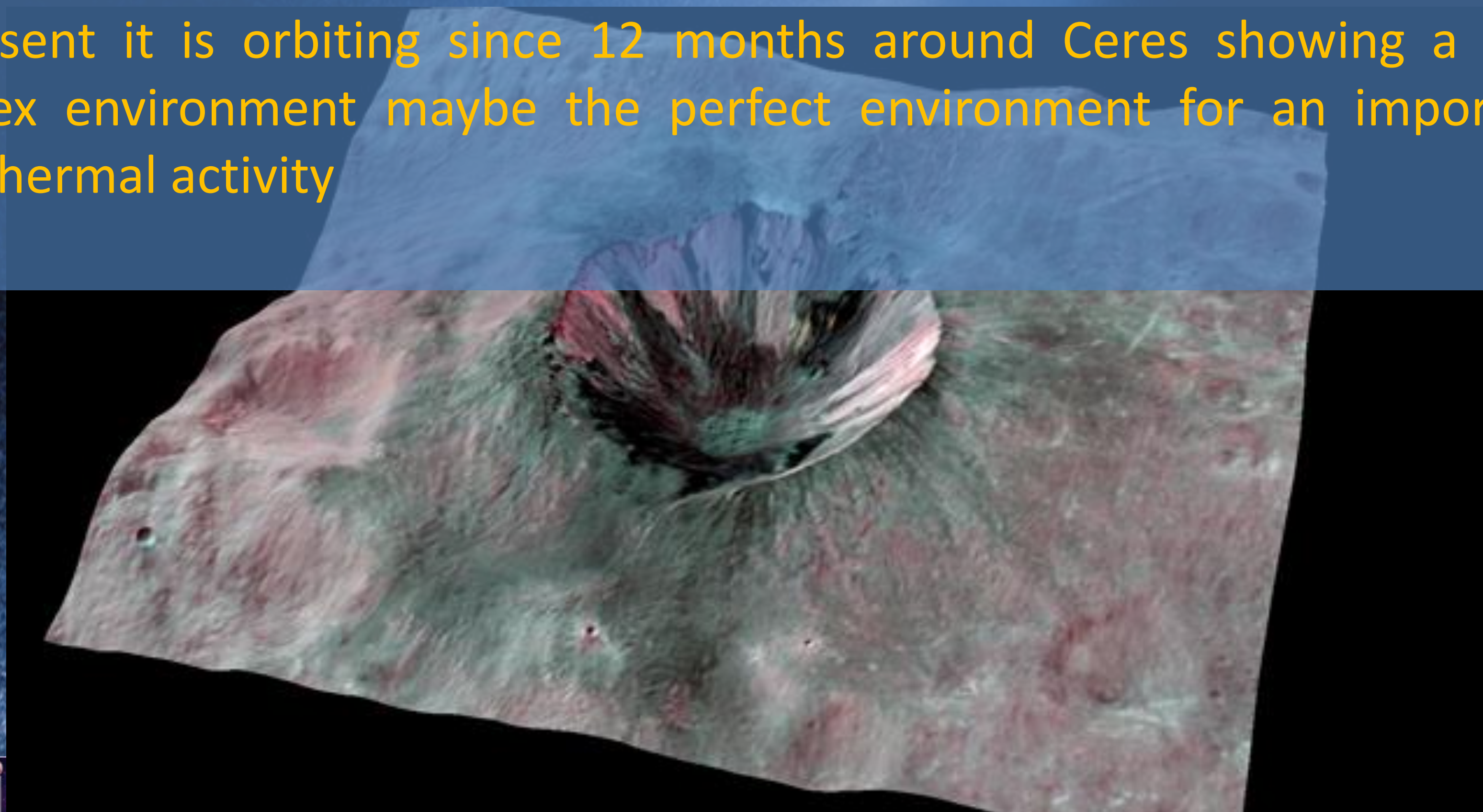
Vesta and Ceres Investigations (1)

The DAWN spacecraft that has been in orbit around Vesta for approximately 14 months and was able to discover geometric the largest albedo ever observed so far for Solar System (before Ceres!!) and an unexpected OH rich object

At present it is orbiting since 12 months around Ceres showing a very complex environment maybe the perfect environment for an important hydrothermal activity



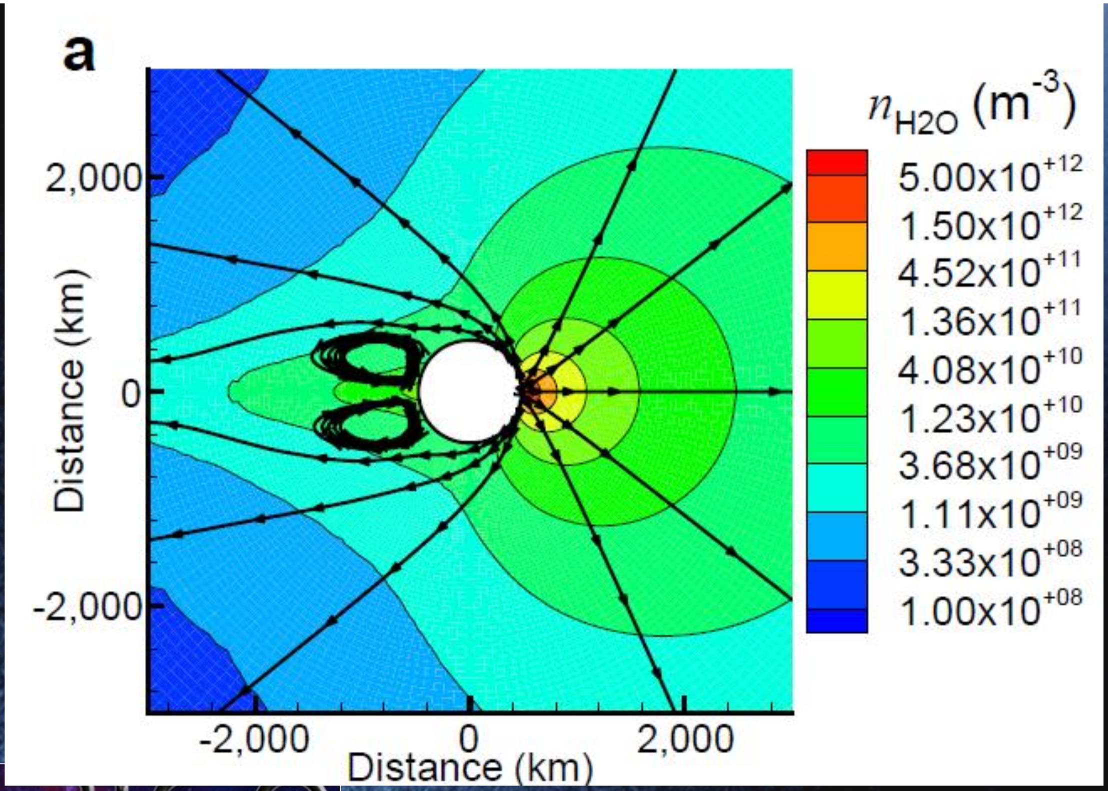
Ceres Investigation (2)

LETTER

doi:10.1038/nature12918

Localized sources of water vapour on the dwarf planet (1) Ceres

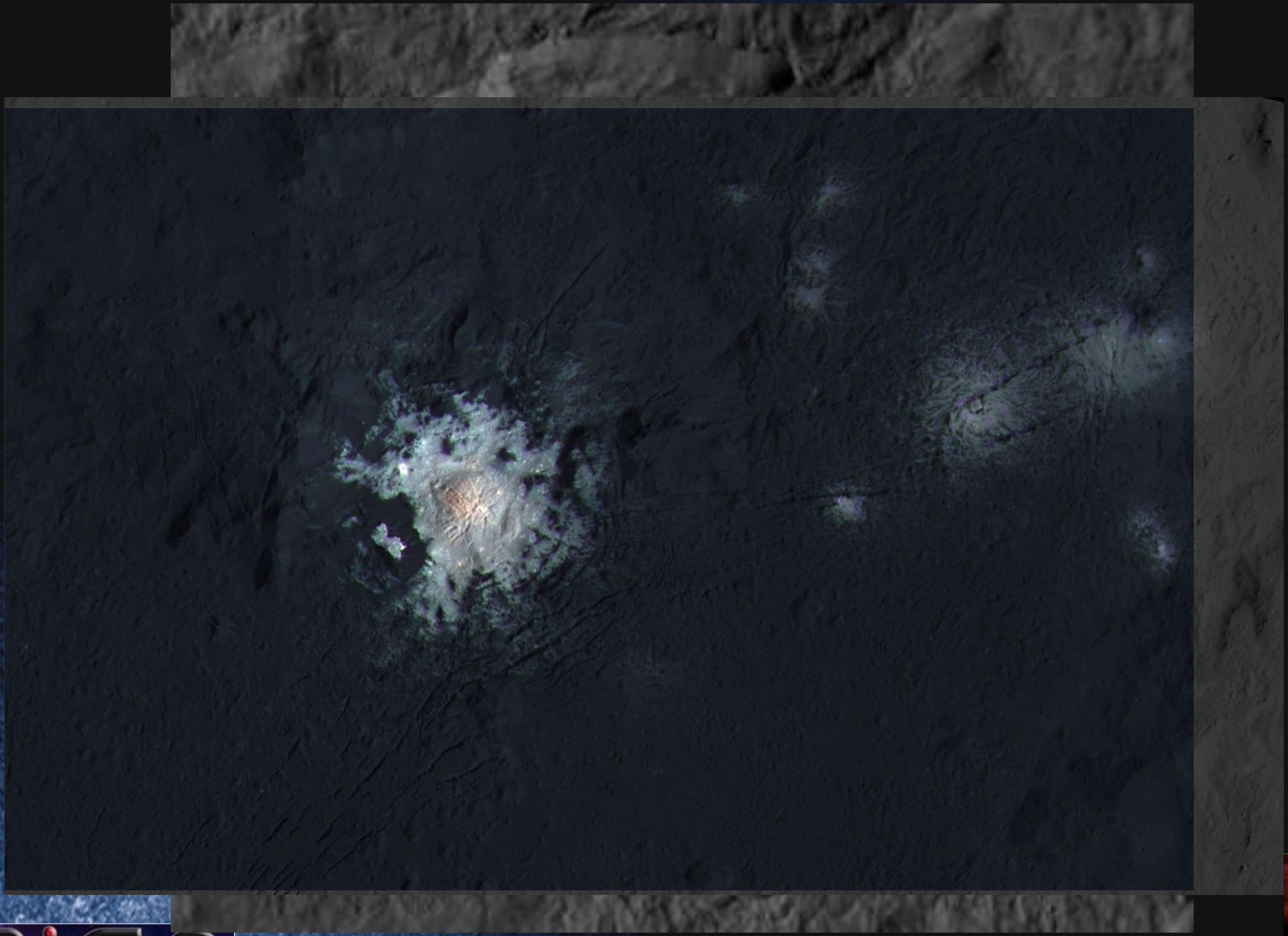
Michael Küppers[1], Laurence O'Rourke[1], Dominique Bockelée-Morvan[2], Vladimir Zakharov[2], Seungwon Lee[3], Paul von Allmen[3], Benoît Carry[1,4], David Teyssier[1], Anthony Marston[1], Thomas Müller[5], Jacques Crovisier[2], M. Antonietta Barucci[2] & Raphael Moreno[2]



2014 Herschel discovery

Water band @ 538 μm

Ceres Investigation (2)



Ceres Investigation (3)

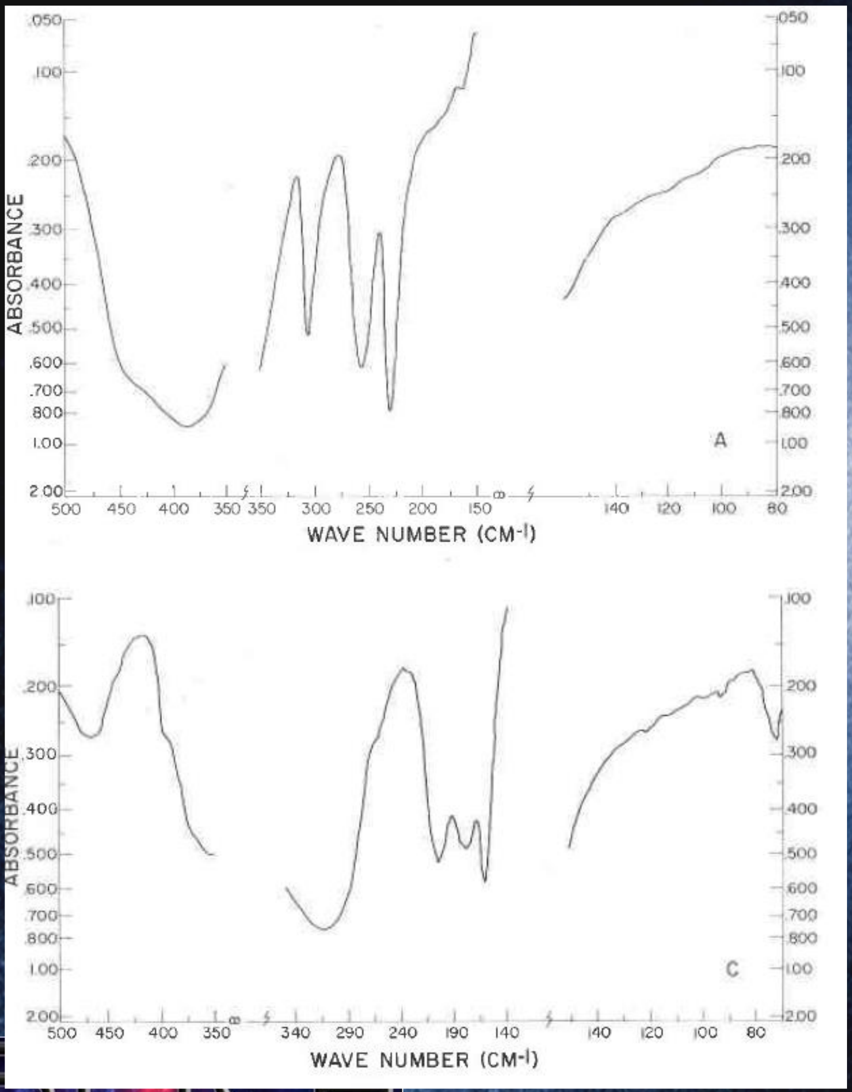
- Are there active hydrothermal processes on the sub surface of Ceres?
- Are there active cryovolcanic processes on Ceres
- Can we detect probe water and/or other molecular compounds resulting from these processes (e.g. CO2) with SPICA?
- Can we characterize the Ceres exosphere and its varation over time?

Vis to IR sources of spectral features of solid materials i.e. surfaces of rocky bodies

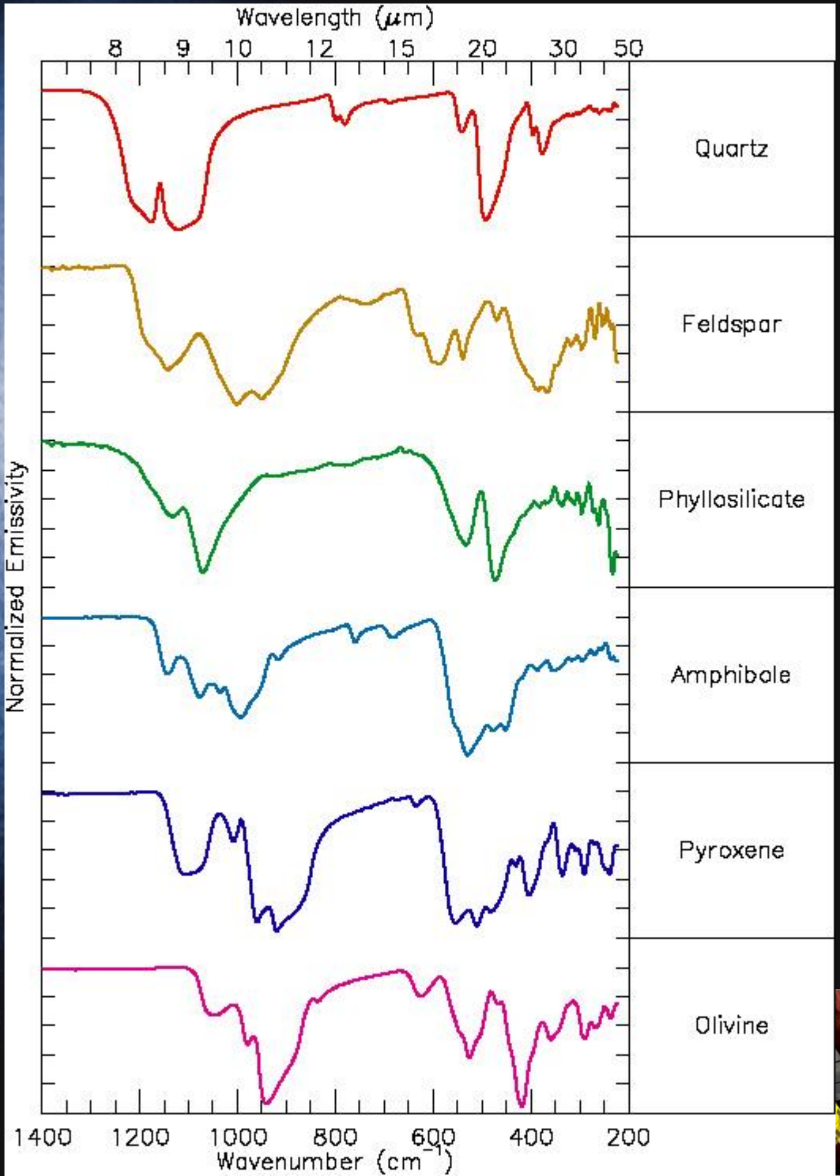
- Two basic types of processes from 0.4 - 50 μm
  - **Electronic** (~0.4 to 2 μm) Vis-NIR
  - **Vibrational** (2~50 μm) NIR-MIR
    - Excitation of fundamental vibrational motions of atoms
      - stretching and bending
      - Frequencies related to strength and length of bonds
    - ~1.5 - ~6 μm are weaker overtones and combination bands
      - Complex transitional region between reflection & emission
  - **Lattice vibration** (>50 μm) FIR
    - Excitation of fundamental vibrational motions of atoms

FIR vs MIR spectra

FIR



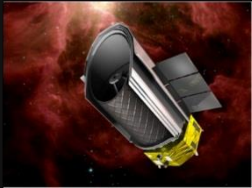
MIR



Vesta Main Enigmas

Vesta's enigmas could be studied by means of MIR-FIR imaging spectroscopy. The Vesta potentially resolvable diameter (0.4-0.6 arcsec) would allow to investigate the mineralogy of large areas of the Vesta surface.

- Composition of dark-hydrated materials
- Detection of plagioclase
- Olivine are present on Vesta?
- Mesosiderites come from Vesta?



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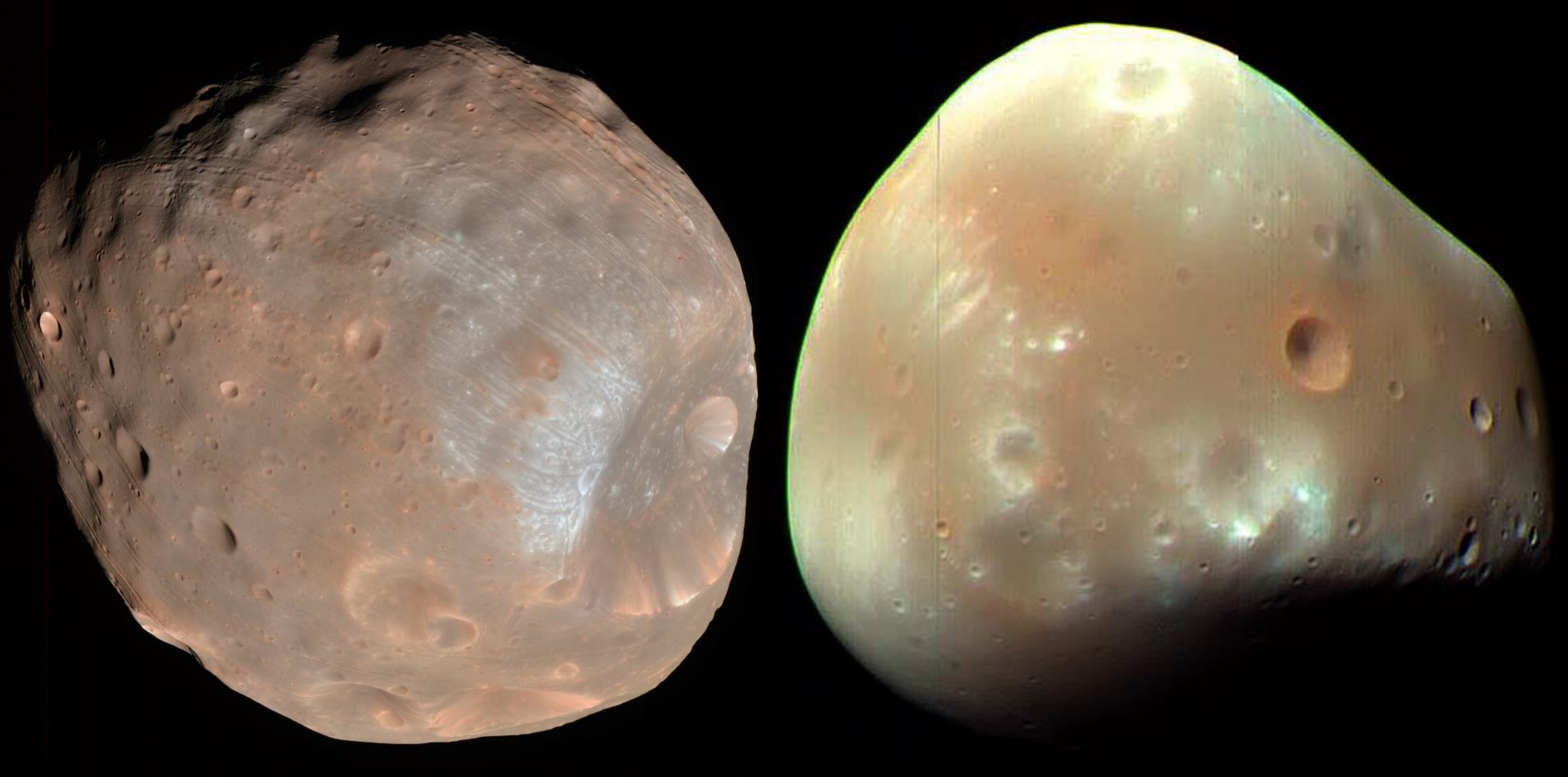
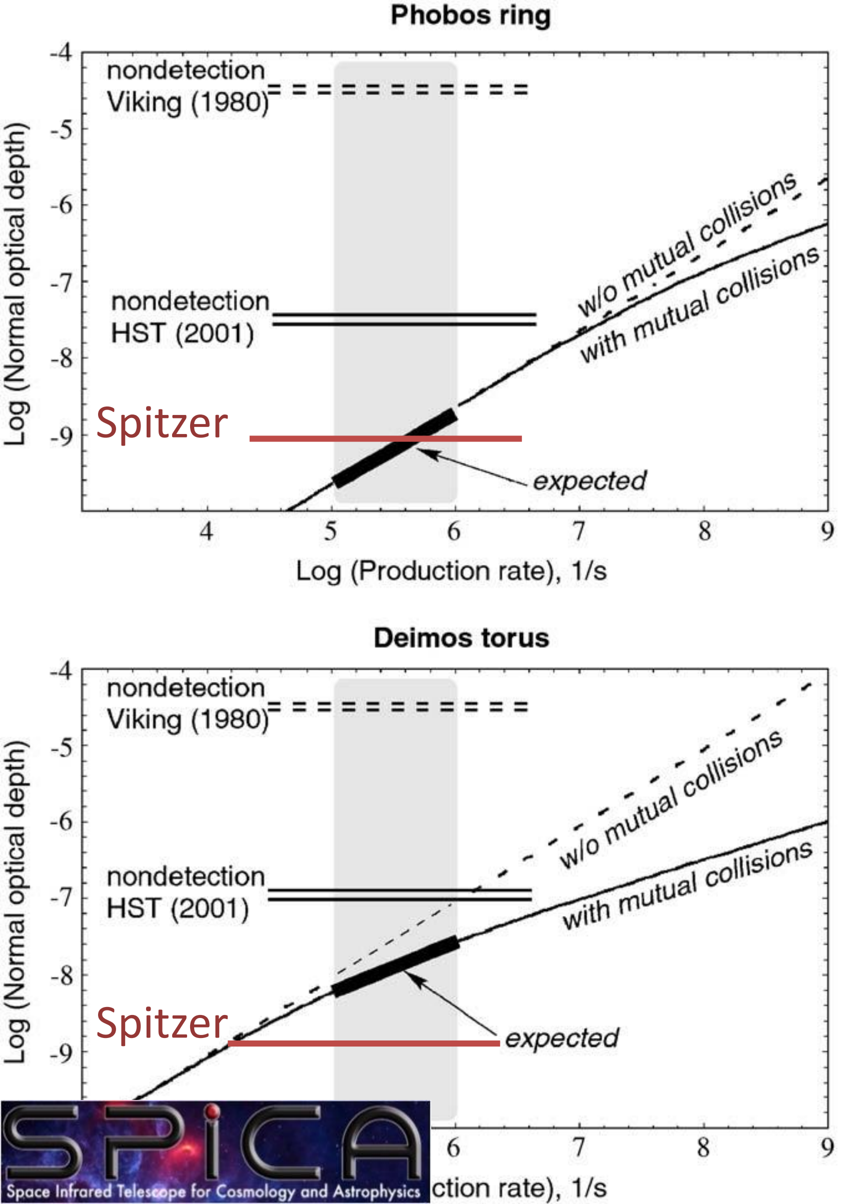
Martian dust Torus (1)

Two tenuous dusty torus should be present around Mars formed by the impact ejecta from the martian moons Phobos and Deimos (Krivov and Hamilton, 1997 and refs therein)



Martian dust Torus (2)



Both belts are seen edge-on and have the maximum optical depth, during Mars' equatorial plane crossings. Of course, the chances to detect the belts are the best if a plane crossing occurs close to opposition, when geocentric distance to the planet is at a minimum.

Martian dust Torus (3)

One of the most promising opportunity to observe the Torus is end of 2022

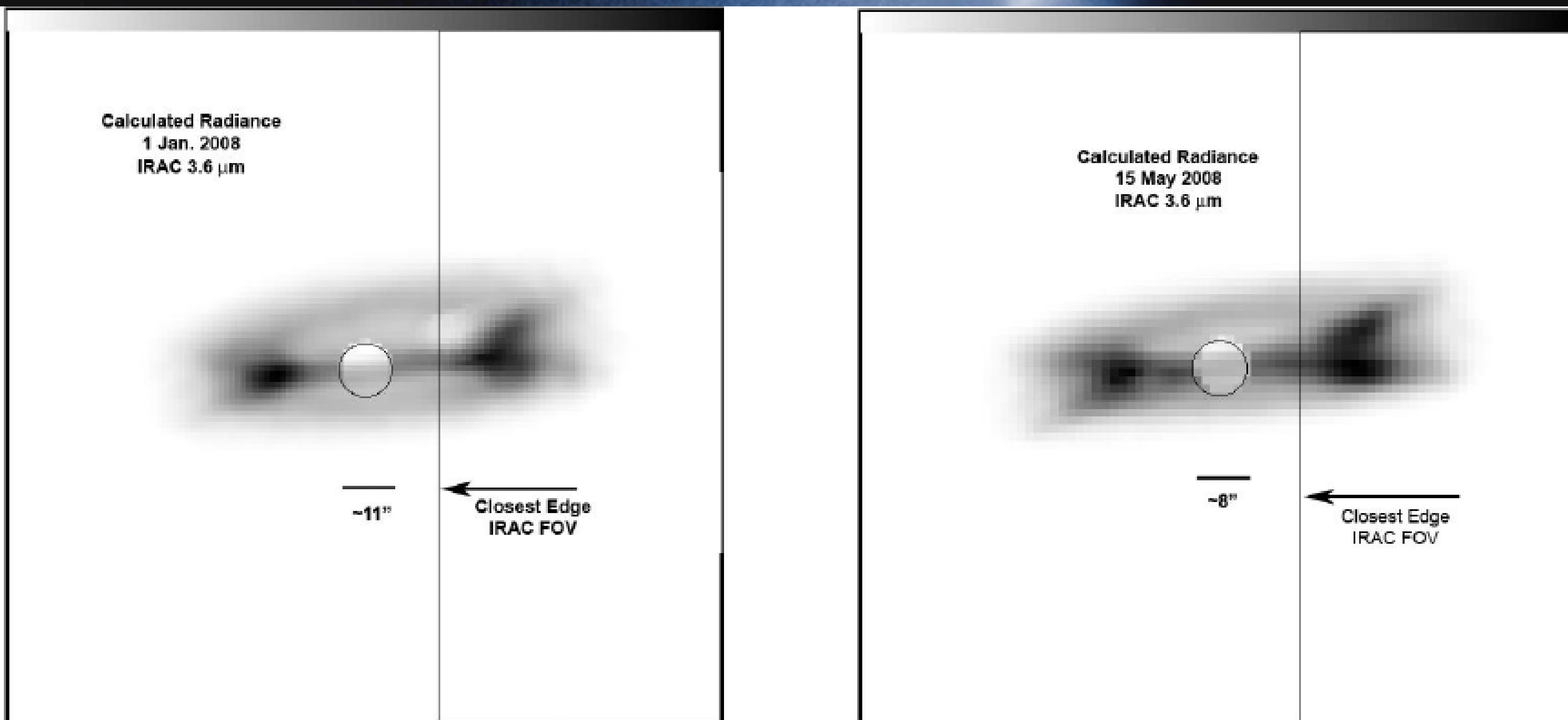


Figure 2. Distribution of the radiation flux from the Deimos torus as seen in on 1 Jan. (left) and 15 May (right) 2008 in the 3.6 μm IRAC filter. Angular resolution on the plots is 1.2″. Dark areas represent the regions of highest flux

Italian Solar System community

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